2. Zou J., Pan J., Wu S., Qian M., He Z., Wang B., Li J. 2019. Rapid control of activated sludge bulking and simultaneous acceleration of aerobic granulation by adding intact aerobic granular sludge. *Science of the Total Environment*, 674, 105–113.
3. Czarnota J., Tomaszek J.A., Masłoń A. 2016. Zastosowanie substancji pylistych w technologii tlenowego osadu granulowanego. *Gaz, Woda i Technika Sanitarna*, 11, 407–412.
4. Czarnota J., Masłoń A., Zdeb M. 2018. Powdered keramsite as unconventional method of AGS technology support in GSBR reactor with minimum-optimum OLR. E3S Web of Conferences 44, 00024. https://doi.org/10.1051/e3sconf/20184400024.
5. Masłoń A., Tomaszek J.A. 2012. Kierunki zastosowania mineralnych materiałów pylistych w technologii osadu czynnego – studium literatury. Prace Naukowe Politechniki Warszawskiej, 59, 5–23.
6. Thanh B.X., Visvanathan Ch., Aim R.B. 2009. Characterization of aerobic granular sludge at various organic loading rates. *Process Biochemistry*, 44, 242–245.
7. Li J., Liu J., Wang D., Chen T., Ma T., Wang Z., Zhuo W. 2015. Accelerating Aerobic Sludge Granulation by Adding Dry Sewage Sludge Micropowder in Sequencing Batch Reactors. *International Journal of Environmental Research and Public Health*, 12, 10056–10065.

INCREASING THE SENSITIVITY OF METHOD FOR PATHOGEN DETECTION IN WATER BASED ON THE SURFACE PLASMON RESONANCE PHENOMENON

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Introduction. One of the biggest global problem is an unsatisfactory condition of water sources and insufficient sanitation, which are responsible for 90% of lethal cases caused by diarrheal diseases all over the world. It is well known, that bacteria are the main causative agent of diarrhea. However, a wide range of viruses that could be found in water sources have a negative impact on human health and cause a number of clinical symptoms of varying severity in human and animals, from pulmonary fever to brain damage [1]. Existing methods of water quality control are long-lasting and require a special valuable equipment and additional reagents. As an alternative and one of the promising could be a method based on the phenomenon of surface plasmon resonance (SPR), that allows to make an express analyzes (duration less than 1 hour) and does not require specific reagents [2]. The principle of pathogen detection by SPR-methodology based on the determination of the SPR-shift whilst an interaction between receptor and analyte (in our case – antigen and antibody) on the surface of sensitive element of SPR-sensor. This procedure requires a washing of sensitive element after interaction to remove analyte, that was not interact with receptor. In addition, it requires to block gaps without receptor on the sensitive element surface to reduce a non-specific interaction, which increase the measurement errors and subsequently decreased the accuracy of results.

Objective of work. Development of a new more accurate express-method for pathogen detection in water by surface plasmon resonance.

Materials and methods. As biomaterials, two antigen-antibody pairs of enzootic leukemia and bovine viral diarrhea and porcine encephalomyelitis were used (viral pathogens of animals from the families *Retroviridae*, *Picornaviridae* and *Togaviridae* respectively). The receptor-analyte interaction was studied by the proposed and existing method of detection that was performed in accordance to the protocol described in works [3, 4]. The proposed method assumed no blocking and washing procedure in experiments. To implement the new detection method, the "Plasmon-6" SPR-device was used. It was developed at the Lashkaryov Institute of Semiconductor Physics of NAS of Ukraine and provides high sensitivity for detection of low concentrations of molecules in liquid and gaseous substances and shows slight error of measurement of the resonance angle (± 3 arc.sec). The research on antigen and specific antibody interaction was held at the State Scientific Control Institute of Biotechnology and Strains of Microorganisms. To provide both specific and non-specific interaction, technological approach on surface functionalization of sensitive element was used [5, 6]. We used the developed method for analyzing the kinetic of antigen-antibody interaction, for which the interaction response of the SPR-shift resonance characteristic was analyzed. The efficiency of the developed method was determined by the relative error of measurement, due to the reference value of the resonance shift after washing of the sensitive element.

Results. For the developed method, the shifts of the resonance angle for the specific receptor-analyte interaction for leukemia, diarrhea and encephalomyelitis were 1440, 591, 426 arc.sec respectively. At the same time, for existing method the shifts of the resonance angle were 1410, 576 and 414 arc.sec respectively. Therefore, the value of relative error was 2.1 – 2.8 %. Furthermore, for non-specific interaction the value of relative error was 15…75% because of the high difference in shifts of the resonance angle which were obtained by the developed and existing methods of kinetic analyzing (426, 192, 85 arc.sec for existing and 166, 49, 75 arc.sec for the developed one). In addition, the presence of functional coating increased the sensor response in 8 times, that approves with our previous results.

Discussion. For all antigens that were used in the research as well as analyzed by developed method, the relative value was in 3 % less in comparison with results that were obtained by existing method which proves a high efficiency of interaction. Moreover, for existing method the relative value was more than 15% because of the non-specific interaction. The results show that developed methodology for pathogen detection in water allows to decrease the relative error at least in 20 times, as well as to reduce the duration of experiment in 1.4 times due to absence of blocking and washing operations.

Conclusions. Presented express-method based on the surface plasmon resonance phenomenon allows to detect pathogens that could be presented in water with higher accuracy and sensitivity, that increasing reliability of obtained results during the monitoring the condition of water sources.

References

1.WHO (2011) Guidelines for drinking-water quality - 4th ed. Geneva, Switzerland: WHO Press.

2. Peng Zhang, You-Peng Chen,WeiWang, Yu Shen, Jin-Song Guo. Surface plasmon resonance for water pollutant detection and water process analysis // Trends in Analytical Chemistry, Vol. 85, (2016), 153–165.

3.Klestova Z., Yushchenko A., Dremuch Yu., Blotskaya O., Venger E., Dorozinsky G., Kravchenko S., Ushenin Yu., Kachur N., Maslov V. Diagnostics of cattle leucosis by using a biosensor based on surface plasmon resonance phenomenon // Semiconductor Physics, Quantum Electronics and Optoelectronics, Vol.22, № 1, (2019), 111–118.

4. Клестова З.С., Ющенко А.Ю., Блоцька О.Ф., Маслов В.П., Ушенін Ю.В., Дорожинський Г.В., Кравченко С.О., Дорожинська Г.В. Експериментально - теоретичне обгрунтування розробки експрес методу виявлення ентеровірусів у воді методом поверхневого плазмонного резонансу. // Innovative Biosystems and Bioengineering, Vol. 3, Issue 1, (2019), 52–60.
5. Oliverio M., Perotto S., Messina G.C., Lovato L., De Angelis F. Chemical Functionalization of Plasmonic Surface Biosensors: A Tutorial Review on Issues, Strategies, and Costs. // ACS Appl. Mater. Interfaces, Vol. 9, (2017), 29394−29411.
6. Shynkarenko O.V., Kravchenko S.A. Surface plasmon resonance sensors: methods of surface functionalization and sensitivity enhancement. // Theoretical and Experimental Chemistry, Vol. 51, No. 5, (2015), 273−292.

MODELING AOB-NOB GROWTH RATE UNDER SPECIFIC OXYGEN STRATEGY FOR OPTIMIZATION SHORT-CUT NITROGEN REMOVAL PROCESS IN WWTPS

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Introduction

The main objective in this paper is the modelling of nitrogen (N) removal technologies principles and operational factors which affect AOB (Ammonia-Oxidizing-Bacteria) and NOB (Nitrite-Oxidizing-Bacteria) kinetics in order to discover more cost-effective strategy in comparison with conventional N removal process in WWTPs. The most promising treatment compared to the conventional nitrification-denitrification (N-D), is deammonification (partial nitritation/anammox) process as well as is partial nitrification and denitrification process. It is based on the partial nitrification (nitritation) up to nitrite followed by the reduction of nitrite to N (denitritation). This process popularly known as short-cut N removal, reduces the aeration requirement by 25% and also the external carbon (C) source by 40% as compared to conventional nitrification-denitrification process, cutting down considerably the energy at WWTPs. Higher denitrification rate and lower wasted sludge production could also be obtained by this process. In the presence of low C/N ratio, and strong nitrogenous wastewater, N removal via AOB-NOB oxygen strategy showed promising results for the process optimization by mathematical modelling and computer simulations.

Due to the sequential oxidation property, the growth balance between AOB and NOB plays a key role in optimization of a nitrifying community. If AOB grows more quickly than NOB, and the